depends. When life no longer exists, then the acids mix with the bases, and the coloured substances spread through the tissues. The simple fact of the death of the protoplasm would therefore suffice, according to M. Prilleux, to explain all the properties of the frozen cells.

As to the sheets of ice which are often seen during the winter at the surface of stems or beneath the epidermis, these originate, according to the same author *, from the water of constitution of the membranes. Each molecule retains around it, by the forces of attraction with which it is endowed, a liquid layer of a certain thickness; under the influence of cold, the force of attraction diminishes, and a part of the liquid flows away and becomes frozen at the surface.

[To be continued.]

XIX.—*Observations on the Systematic Relations of the Fishes.* (Abstract). By Prof. Edward D. Cope†.

I. Preliminary.

The system of fishes, as at present adopted in America, is the result of the labours of many naturalists, but chiefly of Cuvier, Agassiz, Müller, and Gill. Without going into the history of the subject at present, it will be proper to point out the principal modifications of Cuvier's system introduced by his three successors. The orders of Cuvier were:—the Chondropterygii, Malacopterygii, Acanthopterygii, Plectognathi, and Lophobranchii.

Professor Agassiz, under the name of Placoids, adopted the first division; the second he called the Cycloids, the third Ctenoids, and then created a fourth order under the name of Ganoids, which should embrace a portion of Cuvier's Chondropterygii (the Sturgeons), a portion of the Malacopterygii Abdominales (the Bony Gars &c.) and the two last orders of Cuvier. Professor Müller, following with a still more complete anatomical investigation, especially into the soft parts, discerned three subclasses in Cuvier's Chondrostomi, which he named the Leptocardii (Lancelet), Dermopteri (Lamprey &c.), and the Selachii (Sharks &c.). In the then recently discovered *Lepidosiren* he saw a fourth subclass, Dipnoi.

Having instituted an investigation of Agassiz's Ganoid order, in an able memoir he purged it of the Plectognath and

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Lophobranchiate divisions, which are obviously not related to it. These, with the Malacopterygians and Acanthopterygians, he erected into a sixth subclass, the Teleostei. This subclass, containing the greater part of existing fishes, embraced six orders, viz.:—Acanthopteri (Cuvier's Acanthopterygians), Anacanthini (new, for the cod family &c), Pharyngognathi (new, for fishes with connate inferior pharyngeal bones), Physostomi (Malacopterygians of Cuvier, nearly); Plectognathi and Lophobranchii of Cuvier. The great number of facts in the anatomy of fishes added by Müller constitute him the father of modern ichthyology.

Professor Gill, in 1861, adopted many of the divisions of Müller, and rejected some; others were newly proposed. But four subclasses were recognized:—the Dermopteri, which includes also Müller's Leptocardii; the Elasmobranchii, equivalent to Müller's Selachii; the Ganoidei, including here Müller's Dipnoi; and the Teleostei. Six orders were attributed to the last subclass, which were quite different from those of Müller.

Subsequent to this publication, important contributions to the system have been made by Kner, Lütken, Gill, Huxley, &c., which will be noticed at the proper time.

The writer, having been engaged in an examination of the osteology of the bony fishes, and general anatomical studies of the whole, has proposed to point out some further modifications of the received system, which he believes will render it a closer reflection of nature. There are some portions of the skeleton which have been to a great extent overlooked in seeking for indications of likeness and difference of types; and the estimation in which many known characters are held may be much altered on the study of extended material. The skeletons on which the present study is made are one thousand in number—two hundred belonging to the Academy of Natural Sciences of Philadelphia, and eight hundred to the writer, being the collection made by Professor Joseph Hyrtl, the distinguished anatomist of Vienna. This collection has long been known to anatomists in Europe as the most beautifully and reliably prepared in existence, and as valuable as any for study, on account of the fulness of the representation of the various types.

II. Special on the Ganoids.

Recurring to Müller's system, the writer adopts, as characterized beyond dispute, his subclasses or orders of Leptocardii, Dermopteri, Selachii, and Dipnoi, and confines himself at

present to the recent Ganoidei and Teleostei. I have shared in the doubts occasionally expressed by ichthyologists as to the essential distinction of these latter divisions; and an examination into the osteology, with reference to this point, confirms the doubts raised by a study of the soft parts. As is well known, Müller distinguished the Ganoidei by the muscular bulbus arteriosus containing numerous valves, and the connexion of the optic nerves by commissure rather than by decussation. He added several other characters, knowing them, however, to be shared by various other orders and subclasses; and I have selected the only two which seemed to be restricted to the division. Their restriction to it, however, is only apparent; and Kner points out that the peculiarity of the optic commissure is shared by some Physostomi, and that the difference between the number and character of the valves of the bulbus in *Lepidosteus* and *Amia* is quite as great as that existing between *Amia* and some of the Physostomi. After an examination of the skeleton, it is obvious that in this part of the organism also there is nothing to distinguish this division from the Teleostei of Müller. It is true that each of the genera referred to it possesses marked skeletal peculiarities; but they are either not common to all of them, or are shared by some of the Physostomi. If, on the other hand, we compare these genera with each other, differences of the greatest importance are observable, which at once distinguish two divisions—one represented by *Polypterus*, the other by *Lepidosteus* and *Amia*.

In the first place, the basal radii of the pectoral fins of *Polypterus* are observed to be excluded from articulation with the scapular arch by the intervention of three elements, which form a pedicle or veritable arm for the fin. In *Lepidosteus* and *Amia* the radii are sessile on the scapular arch, as in ordinary fishes. The ventral fins present a like difference; the basal radii are long and four in number in *Polypterus*. In the other two genera they are absent, excepting one rudimental ossicle on the inner basis of the fin (two in *Lepidosteus*), precisely as in the Physostomous families Mormyridæ, Catostomidæ, &c. If we examine the branchial apparatus, we find an undivided cerato-hyal, three branchio-hyal arches, and no inner and but two outer bones of the superior branchio-hyals, present in *Polypterus*. In *Lepidosteus* and *Amia* we have the double cerato-hyal, four branchio-hyal arches, with four outer and four superior elements, characters of the typical Teleostei. The maxillary bone of *Polypterus*, instead of being free distally, as in fishes generally, is united with an ectopterygoid and with bones representing, in position at least, postorbital

and malar. In the other genera the relations of the maxillary are as in osseous fishes.

The Sturgeons (Acipenseridæ) agree with *Amia* &c. in all of these points but one, differing only in having the superior cerato-hyal and several of the superior branchio-hyals cartilaginous. The one point of distinction is the extension of the basal radial supports of the ventral fin all across its basis, as in *Polypterus*. The pectoral fin is, on the other hand, much as in *Lepidosteus*. Thus the Sturgeons combine in this one respect the features of both divisions. Both the basal cerato-hyals are cartilaginous in this family; the superior only is cartilaginous in *Polypterus*, *Lepidosteus*, and *Amia*; while both are ossified in the old Teleostei, except in the Eels. In these the inferior is cartilaginous, while the superior is co-ossified to the cerato-hyal. Thus in one unimportant character *Polypterus* agrees with its former associates, but differs more from others of them (the Sturgeons) than from the bony fishes.

Another character of both *Lepidosteus* and *Amia* betokens a certain relationship to *Polypterus*, viz. the complexity of the mandible, especially in the possession of a coronoid bone. But here, again, *Acipenser* only possesses an osseous dentary, while *Gymnarchus* and *Gymnotus* have the angular and articular bones distinct from the dentary, wanting the coronoid and opercular. In most bony fishes the angular is not distinct.

It is thus evident that the subclass Ganoidei cannot be maintained. It cannot be even regarded as an order, since I will show that *Lepidosteus*, *Acipenser*, and *Amia* are all representatives of distinct orders. I hope also to make it evident that *Polypterus* should be elevated to the rank of a subclass or division of equal rank with the rest of the fishes and with the Dipnoi already adopted.

The question may be discussed as to whether naturalists are correct who regard the fishes as representing, variously, from two to four classes. One of these (the Ganoidei) having been already disposed of, it remains to consider the claims of the remainder, viz. the Elasmobranchii (Sharks), Dipnoi, and typical fishes.

If we examine the points in which the whole taken together differ from the Batrachia and other classes above it, we find that these are confined chiefly to the structure of the limbs and the hyoid apparatus. The typical fishes present, however, other important peculiarities, viz.:—1, the existence of two or three distinct bones in the suspensor of the mandible, instead of one; 2, the attachment to these of the opercular bones; 3, the absence of pelvic bones; 4, the suspension of the scapular arch to the cranium; 5, the large development of the pterotic

(Parker, *mastoid* of Cuvier and Owen) is characteristic of bony fishes.

The types of variation in the first point, only distinguish groups of subordinate rank. Thus the suspensor of the mandible in the typical fishes consists of the hyomandibular stapes, quadrate (metapterygoid or incus), symplectic, and mesopterygoid (*quadrato-jugal*, Müller; *quadrate*, Huxley, Elem. Comp. Anat.). In the Mormyridæ, Siluridæ, Polypteridæ, and others, the symplectic is absent; in the Eels of several families both it and the metapterygoid are wanting, reducing the suspensorium to a rod of two pieces. This condition exists in many of the Rays; in others and in the Sharks the inferior element is wanting (Müller, Stannius). An important modification is exhibited by *Chimæra*, where the hyomandibular, which alone exists, is continuous with the cartilaginous cranium, not being separated by the usual articulation.

As to the opercular bones, all are wanting in the Elasmobranchs (Sharks and Rays), while the typical fishes possess four, viz. præoperculum, operculum, suboperculum, and interoperculum. In many of these, however, the suboperculum is wanting; and in the Sturgeons and many Eels there is no præoperculum. In *Polyodon* the interoperculum is also wanting. In *Lepidosiren* the operculum and interoperculum are rudimental. In respect of this point also, the divisions indicated are of subordinate value. As regards the development of the pterotic bone, its history is not yet sufficiently made out to enable us to understand its value. It does not exist in those with cartilaginous cranium (Elasmobranchii). The Elasmobranchs are well known to have the scapular arch suspended freely behind the cranium, as in higher Vertebrates. It is not always attached to the cranium, on the other hand, among true fishes; for in the Eels it is quite as in the Sharks, and the spinous-finned *Mastacembelus* presents the same features.

The characters presented by the pelvic bones and limbs seem to be of higher import. Thus all the bony fishes and Sturgeons lack all the pelvic elements. In the Sharks and Rays they are also wanting; but two elements on each side appear in the Holocephali (*Chimæra*) according to Leydig and Gegenbaur. In *Lepidosiren* a large median pelvic cartilage exists; but which element it represents is unknown. This is evidently a character of high significance. As to the limbs, the peculiarities of *Polypterus* have been pointed out above. They mean nothing less than the development of the elements of the arm and leg of the higher Vertebrata which intervene between

the point of articulation and the distal segments in *Polypterus* and the Sharks and Rays. In the former the distal segments are articulated exclusively to the extremities of the proximal pieces, which thus resemble, as well as represent, humerus and femur, and render the limb pedunculated. The proximal pieces are not continued distally, however, into the representatives of the main axis, which, as demonstrated by the admirable studies of Gegenbaur, consist, after humerus, of radius, tarsals and metatarsals, and thumb; in the hind limb, of the line of the tibia and inner toe. This continuation is observed in the Elasmobranchii, where, however, the divergent segments extend along the sides of the proximal pieces to near, in some Rajidæ quite to the articulation with the scapular arch. In the true fishes, including some of the old Ganoids already considered, the divergent rays always reach this articulation, while the number of proximal or basal pieces is diminished. These pieces have been called by Gegenbaur the metapterygium (humerus), mesopterygium, and propterygium—the first being axial, the second and third being divergent from it. In *Polypterus* the propterygium and mesopterygium are largely developed; in Sharks and Rays the propterygium is sometimes small, sometimes wanting, while in the true fishes the propterygium and mesopterygium are both wanting, excepting in *Amia*, *Lepidosteus*, and the Sturgeons, where a cartilaginous mesopterygium exists, according to Gegenbaur. This author finds it rudimental in young Salmonidæ and Siluridæ. Lastly, in the true fishes the distal elements of the axis of the limb are wanting, just as in *Polypterus*.

In Dipnoi, on the other hand, we have this axis complete or rather with greatly multiplied distal segments, and with or without lateral radii. In the Australian *Ceratodus* Günther finds numerous lateral series on both sides of those of the axial row. Hence the limb of this order is considered by Owen the simplest or primary type; and this proposition is abundantly confirmed by the beautiful researches of Gegenbaur. The foundation laid by this author for the history of the genesis of limbs will ever be a landmark in the history of *modern theories of creation* (see his memoir, "Ueber das Skelet der Gliedmaassen der Wirbelthiere im Allgemeinen," &c., Jenaische Med. Zeitschr. vol. v. p. 397).

Important as are the characters that distinguish the several groups indicated by the different types of structure of the limbs and pelvis, they do not seem to me to warrant their recognition as classes equivalent to those of the six already pointed out. Taking them together, there is a greater coherence also in the structure of the brain and circulatory systems than would be

the case with any other two of the classes adopted above. The peculiarities of the limbs, important as they are, are nearly related in the want of specialization of their parts, seen in the Batrachia and other classes—the differences consisting rather of number and position of similar parts. The pelvis of the Dipnoi might be regarded as of primary importance but for its existence in the Holocephali, whose limbs, again, are so near those of the shark.

It remains, therefore, to adopt the Linnæan and Cuvierian class Pisces, and to grant as subclasses the groups of Holocephali, Selachii, and Dipnoi. There remain as subclasses the groups typified by *Polypterus* on the one hand and the true fishes on the other. The first has been already distinguished in its external characters by Professor Huxley, who again brought light out of obscurity when he established his "third suborder of Ganoids, the Crossopterygidæ." This division is, in my estimation, a natural one, and to be elevated to a rank equivalent to that of each of the three above named, being the only part of the original division of Ganoids of Müller entitled to it. Professor Huxley defined it as follows :—

"Dorsal fins two, or, if single, multiplied or very long; the pectoral and usually the vertical fins lobate; no branchiostegal rays, but two principal, with sometimes lateral and median jugular plates situated between the rami of the mandible; caudal fin diphyocercal or heterocercal; scales cycloid or rhomboid, smooth or sculptured."

Of the above characters, that which relates to the lobate fins is the essential one, and is the expression of the external appearance produced by the structure of the bones of the limbs already pointed out by Gegenbaur. The dorsal fins of some families, it is true, possess a remarkable structure; but in *Phaneropleuron* (Huxley) and some others they appear to be nearly like those of the Dipnoi. The absence of branchiostegal rays is important, but is shared by the Sturgeons. The jugular plates appear to exist in *Polypterus* alone among recent fishes, though several, as *Amia*, *Elops*, *Osteoglossum*, &c., possess a median one. Nevertheless its nature would not lead one to anticipate its being a constant feature in any group of high rank; at least such is our usual experience with dermal bones. The structures of the skin and scales given by Huxley are very subordinate.

The remaining division answers, then, to the Teleostei and Ganoidei of Müller, minus *Polypterus*. The name Teleostei cannot be preserved for this division, owing to its entire want of coincidence with that division of Müller, as well as from the fact that the cartilaginous Sturgeons must be included in it.

I propose, therefore, to call it the Actinopteri. The character of the five subclasses will then be as follows :—

Class Pisces.

The hyomandibular bone continuous with the cartilaginous cranium, with a rudimental opercular bone. Two distinct pelvic bones on each side. Derivative radii sessile on the sides of the basal bones of the limbs, separated from the articulation. *Holocephali.*

Hyomandibular bone articulated with the cranium ; no opercular or pelvic bones. Derivative radii sessile on the sides of the basal bones of the limbs, rarely entering articulation. *Selachii.*

Hyomandibular bone articulated, with rudimental opercular bones ; a median pelvic element. Limbs consisting of the axial line only, commencing with the metapterygium, and with multiplied segments. *Dipnoi.*

Hyomandibular articulated, opercular bones well developed, a single cerato-hyal ; no pelvic elements. Limbs having the derivative radii of the primary series on the extremity of the basal pieces, which are in the pectoral fin metapterygium, mesopterygium, and propterygium. *Crossopterygia.*

Opercular bones well developed on separate and complex suspensorium ; a double ceratohyal, no pelvic elements. Primary radii of fore limb parallel with basilar elements, both entering the articulation with scapular arch. Basilar elements reduced to metapterygium and very rarely mesopterygium. Primary radii of posterior limbs generally reduced to one rudiment. *Actinopteri.*

III. On the Actinopteri.

In determining the primary types of this subclass, we return to some characters already mentioned, in which they approximate to the Crossopterygia, and, adding others, follow the various divergences to their specialized terminations.

Thus in *Acipenser* and allies the ventral fins possess a complete series of basal radial bones, and the pectorals each a large mesopterygium. In *Amia* and *Lepidosteus* the mesopterygium is small, and the basal radii of the ventrals are reduced to their lowest number. In none of them are the basihyals fully developed. Most of the Eels retain a character which we have only observed heretofore in the Selachii.

We pass by a number of the lower fishes before we find the mandibular arch furnished with a symplectic. One of the most important modifications, which is more or less coincident

with a number of others, is that which formed the basis of Bonaparte and Müller's order of Physostomi. The presence of the ductus pneumaticus, which characterizes it, is always associated with the abdominal position of the ventral fins and with cycloid scales, and mostly with the presence of the precoracoid arch, the entrance of the maxillary bone into the border of the mouth, and the non-separation of the parietal bones by the supraoccipital. Yet none of these characters are precisely associated at the point of change in each; for there are physostomous fishes with separated parietals and ctenoid scales (some Cyprinodontidæ), and there are Physoclysti with abdominal ventrals. Nevertheless three prominent types stand out in the Actinopteri—the Sturgeons or Chondrostei, the Physostomi, and the Physoclysti, which may be considered tribes.

An entire series of basilar segments of the abdominal ventral fins; no branchiostegal rays. *Chondrostei.*

Basilar segments of ventrals rudimental, position of fins abdominal, parietal bones usually united; branchiostegal rays; swimming-bladder connected with the stomach or œsophagus by a ductus pneumaticus. *Physostomi.*

No ductus pneumaticus; parietal bones separated by the supraoccipital; ventral fins usually thoracic or jugular; no basilar segments. *Physoclysti.*

Chondrostei.

There are two orders in this division, as follows:—

A precoracoid arch; no symplectic bone; premaxillary forming mouth-border; no suboperculum, nor præoperculum; mesopterygium distinct; basihyals and superior ceratohyal not ossified; interclavicles present; no interoperculum or maxillary; branchio-hyals cartilaginous. *Selachostomi* (the Paddle-fish).

Similar to the last, but with interopercle, maxillary bones, and osseous branchio-hyal. *Glaniostomi* (the Sturgeons).

The first order embraces the single family of *Spatulariidæ*, the second that of *Acipenseridæ*. In both the chorda dorsalis persists, the tail is heterocercal, and the osseous cranium is little developed. The basal and radial elements of the limbs, with the coracoids, are not ossified.

Physostomi.

The following key will express the leading features of the orders of this division:—

I. A precoracoid arch.

A. A coronoid bone.

Maxillary in many pieces; vertebræ opisthocœlian. 3. *Ginglymodi* (the Bony Gar).

Maxillary not transversely divided; vertebræ amphicœlian. 4. *Halecomorphi* (the Dogfish).

AA. No coronoid bone.

* No symplectic bone.

Pterotic simple; anterior vertebræ with ossicula auditus; supraoccipital and parietals coossified. 5. *Nematognathi* (the Catfishes).

Pterotic annular, including a cavity closed by a special bone; parietals distinct; vertebræ simple. 6. *Scyphophori* (the *Mormyri*).

** Symplectic present.

Anterior vertebræ coossified, and with ossicula auditus. 7. *Plectospondyli* (the Suckers &c.).

Anterior vertebræ similar, distinct, without ossicula auditus. 8. *Isospondyli* (Herring &c.).

II. No precoracoid arch.

A. Scapular arch suspended to cranium.

* A symplectic.

Pterotic and anterior vertebræ simple; parietal separated by supraoccipital. 9. *Haplomi* (Pike &c.).

Anterior vertebræ modified; parietals united; pectoral fins. 10. *Glanencheli* (Electric Eel).

** No symplectic.

Anterior vertebræ simple; a præoperculum and maxillary; no pectoral fins. 11. *Ichthyocephali* (Java Eels).

AA. Scapular arch free behind the cranium.

* A præoperculum.

A symplectic; maxillary well developed; no pectoral fins. 12. *Holostomi* (Symbranchi).

No symplectic; maxillary lost or connate; pectoral fins. 13. *Enchelycephali* (Eels proper).

** Præoperculum wanting or rudimental.

No symplectic, maxillary, or pectoral fins, no pterygoid. 14. *Colocephali* (Muræna).

Of the above orders the Haplomi (Pike &c.) approach nearest the Physoclysti of the families Ophiocephalidæ and Atherinidæ, and the Holostomi of the family Symbranchidæ to the Physoclyst family of Mastacembelidæ. The affinities between these families are in both cases so close as to render the distinction of the primary divisions in question hardly worth preserving.

The complete development of the support of the caudal fin

is seen in many members of this tribe, while in others it remains in its primitive condition. Among Physoclysti it is nearly always complete, though in a few (Trichiuridæ &c.) it remains larval. In the first development of the vertebral column in fishes it forms a straight axis. The fin is represented by a fold of the integument which extends equally round its extremity. In this membrane the rays are developed, and in many fishes they remain thus equally distributed. In this case the caudal vertebræ remain in a straight line to the extremity, and we have a termination such as is seen in *Lepidosiren* and the eels. This form of tail may be called the *isocercal.*

If, now, the radii, basal or distal, acquire a greater development on the lower side of the column, those on the upper side remaining rudimental, it will be necessary that such enlarged portion should strike the water in the plane transverse to the longitudinal axis of the body, in order that the weight of the body be propelled with the least expenditure of force. This will necessarily cause the distal vertebræ, or end of the chorda dorsalis, to be turned upward, so that the inferior rays of the fin shall be brought as near to the vertical line of the superior as possible. This is the type of tail known as the *heterocercal*, as called by Agassiz.

We find among the Physoclysti that the lower rays of the fin are more and more strengthened, and the hæmal spines which support them are more and more enlarged; consequently the end of the column is more curved upwards, as seen in *Amia.* The superior rays and neural spines are also strengthened, and the inferior so extended upwards as to pass round the extremity of the column and come into contact with them. And now the vertebral centra are successively atrophied from the extremity. Counting from the extremity to the bases of the first supports of the outer rays of the caudal fin above and below, we find that ten vertebræ remain in the tail of *Notopterus.* In the Hyodontidæ, Albulidæ, Elopidæ, Alepocephalidæ, and Salmonidæ there are but two left, while one only appears in the Osteoglossidæ, Aulopidæ, Lutodiridæ, Butyrinidæ, Coregonidæ, Clupeidæ, and Chirocentridæ. In most other families, especially of Physoclysti, the last one has disappeared, and the numerous hæmal arches are arranged like radii diverging upwards and downwards from the last caudal vertebra. In the highest groups, as Pharyngognathi &c., they become coossified, and the tail has completed specialization. This is the type called *homocercal* or *diphyocercal* by later writers.

These types are thus plainly stages in the development of this member, the first and second being simply arrests of development of the last. Thus the young salmon commences

with an eel-like vertebral column, or is *isocercal*; it presently, by the upward curvature of the column and unequal development of the caudal fin, becomes *diphyocercal*, but ceases to grow before it has quite accomplished this stage. The *Polypterus*, the Eels, *Gymnarchus*, and other fishes ossify the vertebræ in the isocercal stage. The heterocercal type is seen in the Chondrostei, where the vertebræ never ossify. In *Lepidosteus* and *Amia* they ossify in this stage.

I further specify the characters of the orders of Physostomi and the families they contain in the paper itself.

Physoclysti.

The following is an analytic synopsis of the orders. They all have the parietals entirely separated by the supraoccipital, and lack the precoracoid; the symplectic is present, except in *Ostracium*, where it is not ossified.

A. Scapular arch not suspended from the cranium.

Superior branchio-hyals and pharyngeals developed; inferiors and maxillary distinct. 15. *Opisthomi.*

AA. Scapular arch suspended from the cranium.

1. *Ventral fins abdominal.*

Branchial arches well developed, the bones present, except fourth superior pharyngeal; third much enlarged; inferior pharyngeals distinct. 16. *Percesoces* (Mullet &c.).

Third and fourth superior pharyngeals much enlarged, inferior pharyngeals coossified. 17. *Synentognathi* (Soft Gar).

Superior branchio-hyals and pharyngeals reduced in number; inferiors separate; interclavicles present. 18. *Hemibranchii* (Pipe-fishes).

Superior branchio-hyals and pharyngeals and basal branchiohyals wanting; gills tufted. 19. *Lophobranchii* (Sea-horse).

2. *Ventral fins thoracic or jugular.*

First vertebra united to cranium by suture; epiotics united behind supraoccipital; basal pectoral radial bones elongate. 20. *Pediculati* (Goose-fish &c.).

Posterior cephalic region normal, anterior twisted so as to bring both orbs on one side; inferior pharyngeals distinct. 21. *Heterosomata* (Flounders).

Cranium normal; the premaxillaries usually coossified with the maxillaries behind, and the dentary with the articular; pharyngeal bones distinct. 22. *Plectognathi* (File-fishes).

Cranium normal; bones of the jaw distinct; inferior pharyngeal bones distinct. 23. *Percomorphi* (Perch).

Cranium normal; bones of the jaws distinct; third superior

pharyngeal much enlarged, articulating with cranium; inferior pharyngeals coossified. 24. *Pharyngognathi* (Burgall, Parrot-fish).

These orders will be more fully defined, and the families which are referable to them pointed out.

IV. General Observations.

In tracing the affinities of the Physostomi, I have pointed out the relation between the Chrondrostei and the Nematognathi, and between the Halecomorphi and the Isospondyli. The first named of each of these pairs are the structural, and probably genetic, predecessors of the second. The series commenced with the Catfishes may be continued into the Mormyri and then to the families of the Plectospondyli, where the series with altered vertebræ and with ossicula auditus terminates. The Characins, however, have considerable affinity to the Isospondyli, especially in the type of their branchial bones. From the latter group we pass to the Haplomi, and thence to the Physoclyst groups. The eel-like groups form a special line. The Glanencheli have cranial characters of the groups with modified vertebræ, with fins of the more typical eels. The latter show a steady approach in some points to the conditions characterizing the Chondrostei. The loss of the maxillary, of opercular bones, and of pharyngeal elements reminds one of these; but in the loss of the premaxillary and great development of the ethmoid, in the Colocephali, we have features quite unique. The vertebral position of the scapular arch is the only shark-character they possess; while, on the other hand, the Holostomi are undoubtedly related to the *Mastacembelus*, a real Physoclyst with spinous dorsal fin. These relations are as yet entirely inexplicable.

The affinities among the Physoclysti are more clear. Omitting the genus just mentioned, we find the four orders with ventral fins to form a true series, with a Synentognath variation, terminating in the greatly degraded order of Lophobranchii. The Percesoces give us our nearest connexion with the groups with abdominal ventral fins, and lead at once to the Percomorphi. From this centre radiate many lines of affinity. One leads from the Chætodontidæ, through the Acroneuridæ, to the Plectognathi, by the similarity in the arrangement of the posttemporal and forms of the pharyngeal apparatus. An important division of the Percomorphi has the basis cranii simple and the branchials reduced above, viz. the Scyphobranchii. The Cottidæ are the most generalized family of this group, and lead, on the one hand, to the Triglidæ of the Distegi, with which they are generally arranged, and,

on the other, to the Blenniidæ. Some of the latter elongate the basal pectoral bones considerably, and lead to the Batrachidæ on the one side, where the number of these bones is increased, and on the other to the Pediculati, where the number is diminished. To these groups the Anacanthini and Heterosomata are less allied.

The third upper pharyngeal bone has already presented an increase of mass and use in the first orders of Physoclysti with ventral fins. Among the Percomorphi the same increase makes its appearance by little beginnings in some Sciænidæ. It is quite noteworthy in most of the Carangidæ, a group whose separation from the Scombridæ by Günther is supported by this part of their organism. Through forms not now specified, approach to the Pharyngognathi is made. Here the pharyngeals are modified into a mill-like structure, which is least specialized in the Embiotocidæ, and most so in the Scaridæ.

MISCELLANEOUS.

Osteology of the Solitaire.

To the Editors of the Annals and Magazine of Natural History.

Gentlemen,—In a paper on the osteology of the Solitaire of Rodriguez, communicated by my brother, Mr. Edward Newton, and myself to the Royal Society, and published in the 'Philosophical Transactions' for 1869, there occurs the following passage relating to the remains of that bird which had previously come to the notice of naturalists:—

"In addition to these *eighteen* specimens, we are informed that in 1860 or 1861 a tibia, the shaft of a tarso-metatarsal, and some fragments of the shaft of a femur, all of which belonged to the Solitaire, were sent to Professor Owen by M. Bouton, of the Museum at Mauritius; but the fate of these specimens is unknown to us."

In a paper published a few days since in the 'Transactions of the Zoological Society' (vol. vii. part 7. p. 519, note) Professor Owen quotes the above-cited passage, and then, after printing a letter from the late Mr. James Morris, accompanying the specimens to which the information we had received referred, states what they really were, and continues as follows:—

"They were returned to the Museum at Port Louis, Mauritius. The first and sole evidence of Messrs. Newton's interest in these fragments reached me with their memoir. Any previous inquiry would have, at once and most readily, received the reply given in the present note."

Professor Owen makes this statement in error. Some time before our memoir was finished, and therefore before it reached him, my